WISCONSIN AGE FORESTS IN WESTERN OHIO
II. VEGETATION AND BURIAL CONDITIONS

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INTRODUCTION

Much of what is known of Wisconsin vegetational history has come through study of bog deposits and, although wood fragments have been found rather widely in space and time, little concerted effort has been made to utilize them in interpreting the vegetation, climate and glacial history of the period. In the studies here reported, Wisconsin forest remains of three distinct time periods (ranging from 8,500 to more than 40,000 years ago) were investigated from 14 localities in Ohio and one in Indiana in order to determine the nature and fate of the forest cover, and to relate the rate of periglacial tree growth to probable speed of ice advance.

METHODS

Procedures followed were quite simple. In the case of logs, entire specimens, or portions of larger ones, were dug from the banks of streams, quarries, or cuts, bagged and numbered in the field, with a complete stratigraphic record kept by Dr. Goldthwait. Where cones, needles, etc. were found, samples of the encompassing material (till, etc.) were collected to be carefully washed apart in the laboratory. Identification of the woods to genus by their microscopic anatomy involved merely sectioning in the cross, radial, and tangential planes, generally with razor blade, occasionally by sliding microtome, and staining on the slide in dilute alcoholic safranin (1% in 50% ethanol). (It is not ordinarily possible to distinguish species on anatomical bases alone, although in some cases subgeneric groups can be differentiated, e.g., white- and red-oak groups, soft and hard maples, etc.) Examination was made at 150x and 645x.

Annual ring widths were measured with ocular micrometer, generally in radial section at a magnification of 100x, but occasionally in cross-section at 10x.

OLDEST FORESTS

Identifications were made from all of the Ohio locations having radiocarbon dates of more than 32,000 years which are reported in Part I. These are summarized in table 1. Inasmuch as these specimens are all old enough to make C^{14} determinations only very approximate, an exact sequence of vegetation, and hence of climates, is difficult to work out with certainty. With present evidence, it is clear only that both cold- and mild-climate forests occurred more than 32,000 years ago, but whether one followed the other or whether both existed more or less simultaneously in different parts of the state cannot yet be determined. For example, at two locations, Kirkwood (W–415) and Gahanna (W–263), both reported as "more than 37,000 years," only *Picea* (spruce) has been found, representing the same kind of cold-climate evergreen forest which was to be so widespread in Ohio near the ice perhaps 10,000 or 20,000 years later. On the other hand, the remaining two localities, Northampton (W–152) and Germantown (W–96), reported as "more than 40,000 years" and "more than 34,000 years," respectively (i.e., seemingly the *oldest* and the *youngest* of this particular age group), consist only of Angiosperms (table 1). Together with the reports of Orton (Part I, p. 211), a mild period of unknown duration more than 34,000 years ago is indicated for the southwestern quarter of Ohio.

Identified material from Kirkwood (W–415), Germantown (W–96), and Gahanna (W–263) is either a part of the dated sample itself, or, if not, it is so compressed, contorted and/or mineralized that correlation with dated samples is certain. In the case of the Northampton (W–152) material, the original specimen was sent in for radiocarbon determination before the writer's association with the project, hence no personal examination of it could be made. However, Dr. W. L. Stern of the Yale School of Forestry, in personal communication by Dr. R. F. Flint of the Yale Geochronometric Laboratory to Dr. Goldthwait, reports that the original W–152 specimen is either *Robinia* (black locust) or *Maclura* (osage orange), two genera whose wood can be distinguished only chemically. This identification, together with the others which were made by the writer and which are reported in table 1 for the Northampton site, indicate the same kind of mild period as is suggested by the Germantown (W–96) specimen of oak. Since it is possible to date these two sites only as "more than 40,000 years" (Northampton) and as "more than 34,000 years" (Germantown), it cannot be established at present whether or not they represent a single mild-climate period, although that is, of course, the simpler explanation.

TABLE 1

Localities and identifications for specimens greater than 34,000 years old

Locality	County	Woods				
		Picea	*Quercus*	*Fraxinus*	*Fagus*	Other*
Northampton (W–152)	Clark		1	2	2	1*
Kirkwood (W–415)	Shelby	3				
Germantown (W–96)	Montgomery		1			
Gahanna (W–263)	Franklin	1				

Figures for genera represent number of specimens. Radiocarbon laboratory numbers are given in parentheses in column one.

*This is the original specimen on which the radiocarbon age determination was made, and was not seen by the writer. It was identified by Dr. W. L. Stern of the Yale School of Forestry as "either *Robinia* (black locust) or *Maclura* (osage orange)."

FORESTS OF INTERMEDIATE AGE

Forest type.—Collections and identifications of plant material approximately 16,600 to 23,000 years old (see p. 213) were made from eight of the Ohio localities discussed in Part I. These are listed in table 2. The Cuba (Y–448, Clinton County) specimen, which was identified but not collected by the writer, is from a farm pond excavation on the outermost slope of the (terminal) moraine; all the remaining localities are stream cuts where many logs, some to more than a foot in diameter, are readily visible, protruding from the steep banks (fig. 1). There were no stumps in place, but a few specimens resembled uprooted stumps.

Being embedded *in* till (Part I), it is apparent that these represent forests invaded by the glacier. The appearance and condition of much of the wood strongly suggests that the trees were actually alive and growing, although more and more slowly, as the ice gradually overrode them. For example, in many specimens the bark is bruised but tightly adherent to the wood, whereas, had the trees been dead when overridden, the bark should have been shed entirely. Bent and broken specimens are irregularly splintered at the break, not cleanly snapped as is true of dead wood. Moreover, many specimens from five separate localities in Butler and Ross Counties (Oxford W–92, Darrtown Y–450, Westchester W–304, Anderson Run W–331, and Biers Run W–91) show marked decrease in growth ring size during the last years of growth. The significance of this as regards rate of ice advance is discussed below. All of these facts to us clearly indicate movement of the ice into living forests, much as photographed by Lawrence (1950) along Taku Glacier in Alaska.

The remarkable preservation of bark and stubs of branches as well as the absence of well-worn, rounded or gouged surfaces all indicate only short transport of these logs by the ice and suggest that they could hardly have been moved over half a mile from their original growth sites. This conclusion is further borne out by the occurrence of specimens in large groups in nearly every case.

FIGURE 1. Stream cut at Biers Run, Ross County, Ohio (W–91), showing typical collecting locality with logs protruding from banks. These specimens are all *Picea* (spruce).

As shown in table 2, of the 180 specimens of wood of intermediate age which were examined, 176 are spruce (*Picea*). In addition, four collections of needles of white spruce (*P. glauca*) were made. Wright (1920, pp. 598–600) refers to "red cedar" logs observed at Darrtown (Y–450), but there is no indication that this was more than a passing macroscopic judgment. Although several of the specimens obtained at this location in the present study were dark reddish-brown in color, their microscopic anatomy is clearly that of spruce.

The occurrence of such a single strong dominant species is not surprising for, although in the northern evergreen forest today, spruce is commonly associated in bogs with tamarack (*Larix laricina*) and, on upland areas, with fir (*Abies balsamea*), Heusser (1952, 1954) and others find periods of spruce dominance in their Alaskan studies. Sears (1930, 1948) and Potzger (1951) also record the existence of a considerable period of forest with spruce as the single dominant (sometimes comprising 100% of the pollen count) in their bog studies in northern Ohio and along the Wisconsin boundary in various parts of eastern United States. Rosendahl (1948) concludes, "A heavy preponderance of white spruce in the Pleistocene forests of Minnesota is evidenced not alone by its nearly universal occurrence but also by the great amount of spruce wood recovered from many of the sites. . . . Wherever wood of other species has been found, it is always in very minor quantity compared with spruce."

The picture which emerges for southern and southwestern Ohio when the ice arrived in the area 16,600 to 23,000 years ago, is one of cool climate, but which was becoming gradually cooler and moister and, close to the ice, almost subarctic, supporting on areas of glacial outwash a coniferous forest probably relatively narrow in width and composed largely of spruce (in the main white spruce, *Picea glauca*). (For example, Braun (1951), in discussing refugia of the deciduous forest during the Wisconsin, concludes that, with depression of altitudinal forest zones south of the ice, "this would bring the deciduous forest zone to the plateau level about 50 miles south of the ice.") That at least scattered acid swampy areas of tamarack (*Larix laricina*) also occurred is suggested by three collections of this

TABLE 2

Localities and identification summary for specimens of 16,600 to 27,500 year-old age group

		Woods			Needles
Locality	County	Picea	Larix	Thuja	Picea glauca
Brush Creek (W–414)	Shelby	2			
Holes Creek (W–37)	Montgomery	1			
Westchester (W–304)	Butler	18			1
Darrtown (Y–450)	Butler	20			
Oxford (W–92)	Butler	24			
Biers Run (W–91)	Ross	67	1		
Anderson Run (W–331)	Ross	43	2	1	3
Cuba (Y–448)	Clinton	1			

For woods, figures represent number of *specimens:* for needles, number of *samples* containing needles is listed. Radiocarbon laboratory numbers are given in parentheses in column one.

species in Ross County (table 2). Undoubtedly some of the spruce wood from Anderson Run (W–331) and Biers Run (W–91), then, is black spruce (*Picea mariana*) although all three of the needle collections (Anderson Run, W–331) are white spruce. The single specimen of white cedar (*Thuja occidentalis*) from Anderson Run (W–331) indicates the occasional presence of this species, either along rocky banks of meltwater streams flowing from slowly advancing or fluctuating ice somewhere to the north or, less likely, in occasional calcareous swamps. *Picea* does not now occur natively in Ohio; *Larix* occurs in the northeastern counties of Portage and Stark, and *Thuja* is found only locally in the southwestern quarter of the state (Adams, Green and Champaign Counties). Such forests now exist widely in Alaska, Canada and Labrador, extending south into the United States in Minnesota, Wisconsin, Michigan, and New England.

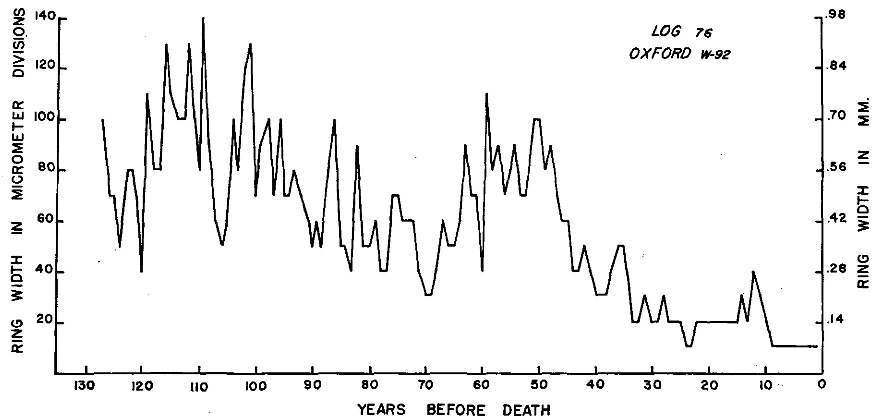
Annual rings and rate of ice advance.—Perhaps the best evidence for feeling that we are dealing here with living forests overwhelmed by advancing ice is the marked and progressive decrease in annual growth ring width noted in many specimens from Butler and Ross Counties, the southernmost of this study. Only logs in which the presence of attached bark indicates that record of the complete life span of the tree is preserved are considered here. This decline in ring width extended generally over the last 50 to 100 years of life of individual trees, and reflects a gradual deterioration in growing conditions ostensibly due to ice approach. Rosendahl (1948) found the same condition (over the last 20 rings) in spruce of early Wisconsin in Minnesota, as did Mathews (1951) in southwestern British Columbia. Regarding this decrease in ring width, Mathews says, ". . . the retardation of growth may be attributed to the gradual approach of the glaciers, which seem to have been directly responsible for (the trees') untimely ends . . . this influence of the glacier on tree growth does not extend far beyond its front. . . ." Rosendahl (1948) comes to much the same conclusion. Many investigators have noted a marked responsiveness of spruce to temperature, the effect being chiefly through lower summer mean temperatures (Hare, 1950).

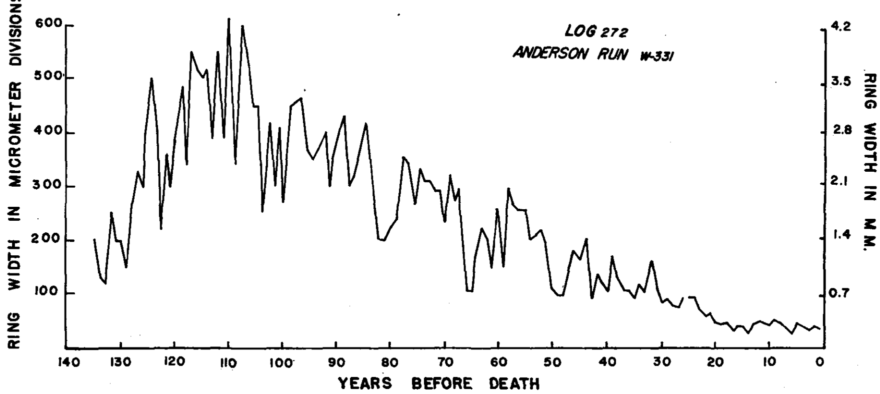
It does not seem plausible that these trees could have been drowned, either on grounds of stratigraphy or because of the length of time over which growth diminution occurred. Likewise, senescence can be eliminated since most of the logs were only 100 to 160 years old at death, whereas spruce has a usual life span of 250 years or more. Finally, the small diameter of many of these trees for their age suggests that they lived in a pretty rigorous climate.

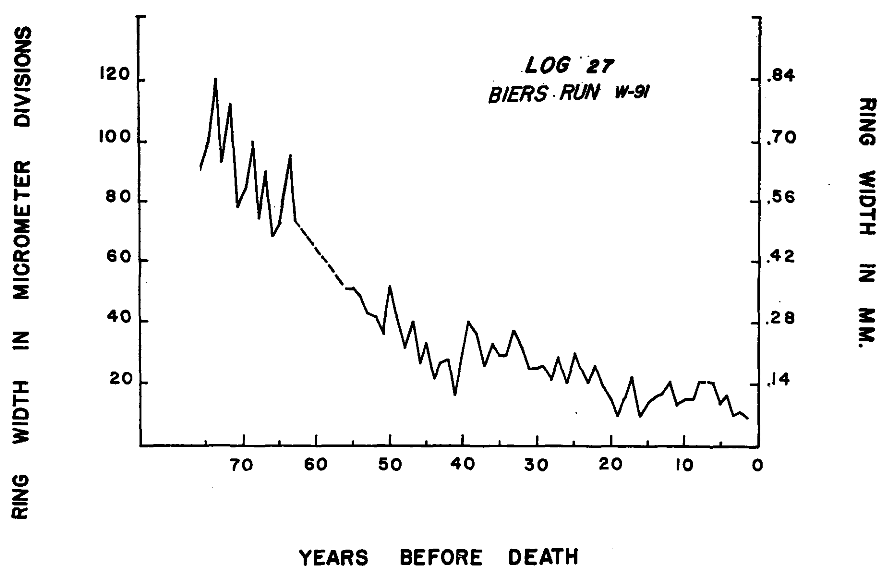
Ring measurements were made on material from all localities studied. Some of these are shown in graph form in figures 2 to 7. Note that Oxford (W–92), Anderson Run (W–331), Biers Run (W–91), and Darrtown (Y–450) are consistent with each other in showing a marked decrease in annual growth to have begun 50 to 97 years before death. A good bit of material for Westchester (W–304), because of mineralization, did not lend itself as readily to graphing since long blocks of consecutive rings could not be measured accurately. The single one represented in figure 7 indicates growth rate decrease to have occurred over the much longer period of about 160 years. This may not be typical for this locality, for Westchester log #230 (mineralized) does show a progressive decrease in ring width from 0.53 mm down to 0.16 mm in what is estimated to be the last 60 years of life. The outermost individual rings in this specimen were composed of one to a few rows of narrow cells, a situation similar to that which Rosendahl (1948) observed in his Minnesota Pleistocene material. The nature of the outermost rings here suggests that this tree spent its last years quite close to the ice where winter-summer temperature differences were slight and soil temperatures low. Another Westchester log, #224, shows a gradient of ring width from 1.82 mm down to 0.25 mm over about the last 80 rings. It is felt, therefore, that Westchester (W–304) material is generally consistent with the other Butler and Ross County locations.

The largest unknown factor in relating this decreased growth to the speed at which the ice was approaching is precise knowledge of the width of a sufficiently refrigerated zone, as to both air and ground water temperature, out ahead of the ice to produce such effects on the growth of (white) spruce. From the work of Mathews (1951) in British Columbia, it would appear that this zone is no wider than a half mile, and perhaps less.

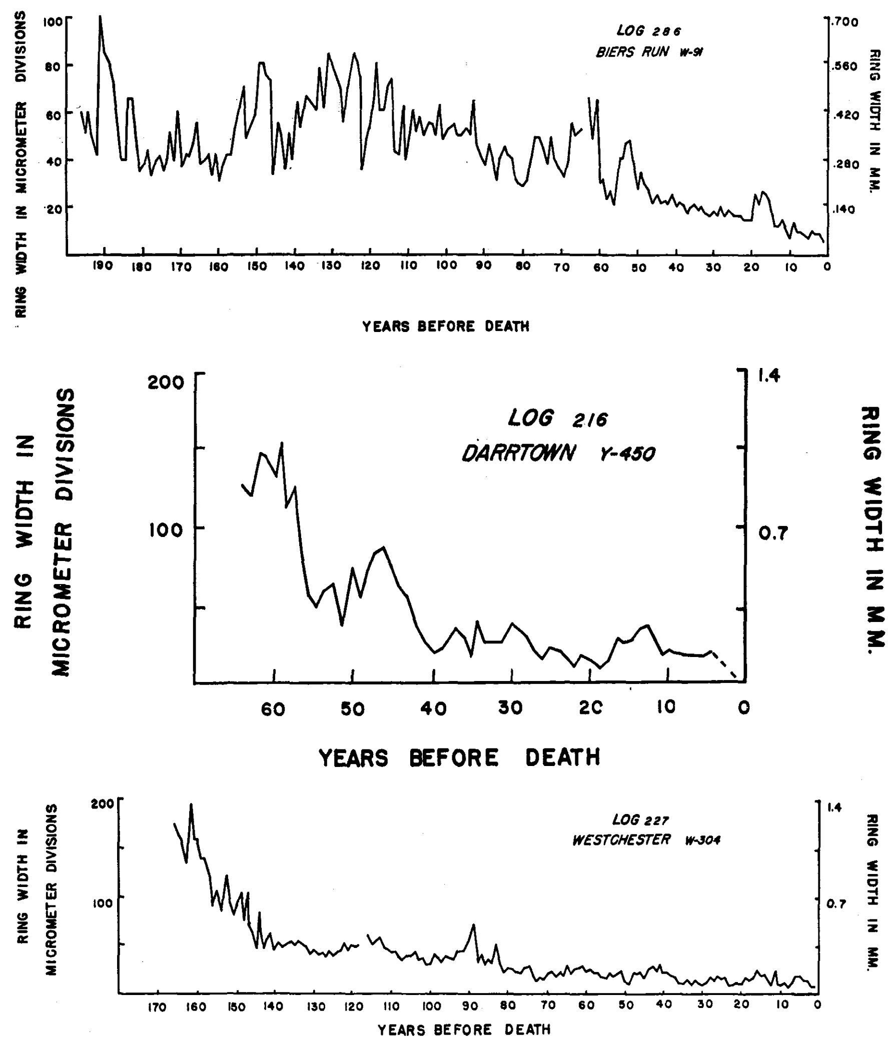
Using an average figure of 70 years for the period of marked growth diminution, and a half mile as the width of the effective zone of refrigeration, an average net advance of the ice of about 38 feet per year is arrived at for the Butler and Ross County localities. This is a little lower than, but quite compatible with, speeds calculated by Dr. Goldthwait from comparative radiocarbon dates along known lines of ice flow in southern Ohio (Part I) and actually suggests a verification of the estimate of one half mile as the width of the zone of refrigeration. The figure of approximately 38 feet per year, based on growth pattern, seems even more appropriate when it is remembered that the Oxford (W–92), Darrtown (Y–450), Westchester (W–304), Anderson Run (W–331), and Biers Run (W–91) sites lie only about 3 to 16 miles inside the limits of maximum southward ice advance. Just as the ice moved more rapidly southward in northern than in southern Ohio, so should it have been decelerating progressively still more as it neared its southern limit.


LOG 76
OXFORD W-92
RING WIDTH IN MICROMETER DIVISIONS
RING WIDTH IN MM.
YEARS BEFORE DEATH


LOG 272
ANDERSON RUN W-331
RING WIDTH IN MICROMETER DIVISIONS
RING WIDTH IN MM.
YEARS BEFORE DEATH


LOG 27
BIERS RUN W-91
RING WIDTH IN MICROMETER DIVISIONS
RING WIDTH IN MM.
YEARS BEFORE DEATH

FIGURES 2–4



FIGURES 5–7

Whereas, then, comparative C^{14} dates tell a great deal about rate of advance over fairly long distances, study of tree growth rings permits a detailed interpolation of average rates of advance or retreat over very small distances as well as a measurement of small fluctuations over periods of time reckoned in decades or less. In other words, by the two complementary approaches of comparative dating and ring measurements, it should be possible to reach a fairly clear picture of both major and minor perturbations in the ice front wherever suitable material, ancient or living, is available.

YOUNGEST FORESTS

Collections were made at three of the "young" sites reported in Part I of this paper. These, and the nature and identification of the material at each, are shown in table 3.

Materials from Erie County, Ohio, (Parkertown, W–430) and Steuben County, Indiana, (W–65) show C^{14} dates of close to 13,000 years (pp. 217–18, whereas other radiocarbon evidence indicates that the ice, in its southward advance must have passed through this part of the country about 24,000 years ago. It is therefore clear that forests at these two localities, although again spruce in the main, must have developed *after retreat* and were not buried under the same conditions as those in southern Ohio. Stratigraphy (pp. 217–18) also indicates this.

Because of the predominance of spruce and the presence of other boreal species, it is evident that the climate, at least at the time of their establishment, was cold, much like that of periglacial southern Ohio some 7,000 years earlier. The association is either spruce-fir or spruce giving way to spruce-fir, but with admixture of hemlock. Hemlock, which today extends farther south than either spruce or fir, is still found locally even in southern Ohio. In Pleistocene collections it is indicative of a moist and cool, but probably warming climate. No evidence suggesting periglacial tundra was found.

TABLE 3

Localities and identification summary for specimens of 8,500 to 14,000 year-old group

Locality	County	Woods												Needles				Cones		Seeds
		Picea	Abies	Tsuga	Fraxinus	Acer	Cornus	Juniperus	Carya	Populus	Quercus	Carpinus	Ulmus	Picea glauca	Picea mariana	Abies balsamea	Tsuga canadensis	Picea glauca	Picea mariana	Picea
Parkertown (W–430)	Erie	25	2	2										1	2	1	2	1	1	
Indiana (W–65)	Steuben	8												2	2			1		2
Castalia (C–526)	Erie				16	9	1	2	2	2	1	1	1							

For woods, cones and seeds, figures represent number of *specimens;* for needles, number of *samples* containing needes is listed. Radiocarbon laboratory numbers are given in parentheses in column one.

Whereas the forests in southern Ohio were killed in being overridden by advancing ice, a similar end cannot have come to these northern forests. The stratigraphy (pp. 217–18) suggests drowning as the likely cause. This conclusion also appears to be borne out by the annual growth of the trees, many of which perished in the short space of less than a decade, as compared with a progressive slowing of growth over nearly a century in southern Ohio forests. Presumably, by the time glacial lakes had lowered again and new forest growth could succeed the drowned cold-climate evergreen association, sufficient warming had taken place to permit entry of modern broad-leaved angiosperm forests, though this is merely surmised at present.

The Castalia, Ohio (C–526), collection represents an entirely different situation from the Parkertown or Indiana forests. Specifically, the Castalia woods are about 4,500 years younger, they are almost entirely composed of Angiosperms, and they grew under very different physiographic and climatic conditions.

In order to evaluate these specimens properly, some explanation of present and past conditions in this part of northern Ohio is necessary. Climax forest today there generally is beech-maple, westward giving way to patches of prairie, especially on old glacial lake beds, with many wet areas having a characteristic succession culminating in a distinctive elm-ash-soft maple swamp community. This latter is reported to occupy much of the area within the old beach lines of Lakes Maumee, Whittlesey, and Warren according to Sampson (1930) who says, "The composition of the swamp forest is dependent in part upon previous vegetational history. The physiographic sites in which the swamp forest of northern Ohio has developed are old lake beds, floodplains, and pre-erosion post-glacial flats. . . . On certain pre-erosion post-glacial flats the deciduous swamp forest communities undoubtedly succeeded forest communities of the northern evergreen forest, such as spruce, balsam, arbor-vitae, birch, and probably hemlock and white pine during the later post-glacial migration."

Characteristic species of this forest community, according to Sampson (1930) are: cottonwood (*Populus deltoides*), black ash (*Fraxinus nigra*), silver maple (*Acer saccharinum*), red maple (*Acer rubrum*), yellow birch (*Betula lutea*), American elm (*Ulmus americana*), sour gum (*Nyssa sylvatica*), and swamp white oak (*Quercus*

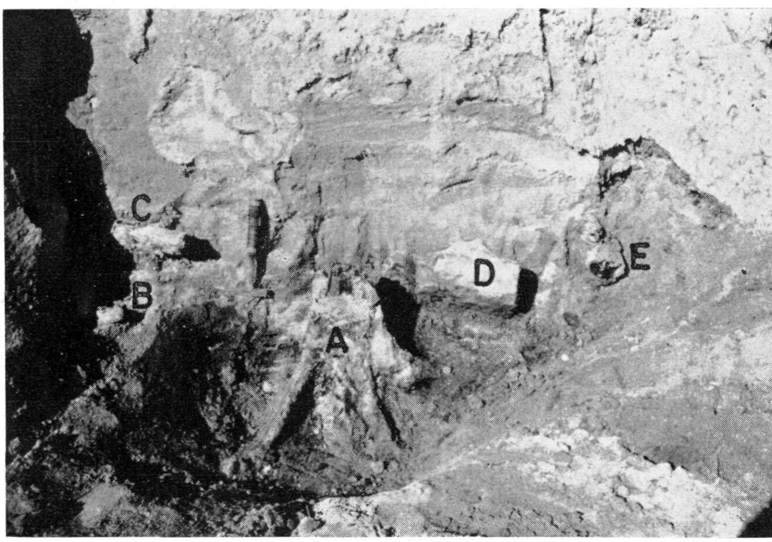


FIGURE 8. Buried stump (A) in place at Castalia, Erie County, Ohio (C–526). This specimen is *Fraxinus* (ash) and measured 10 inches in diameter. Note horizontal logs at B, C, D, and E.

bicolor). The list of genera reported here for the Castalia collection is nearly identical: *Fraxinus*, *Acer*, *Populus*, *Ulmus*, and *Quercus*. Sampson (1930) notes that in certain successional stages from the swamp forest, the following species occur as drainage improves: white ash (*Fraxinus americana*), blue beech (*Carpinus caroliniana*), several species of hickory (*Carya*), oaks (*Quercus*), red elm (*Ulmus fulva*), dogwood (*Cornus florida*), basswood (*Tilia americana*), buckeye (*Aesculus glabra*), black cherry (*Prunus serotina*), beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), etc. Of these, ash, blue beech, hickory, and dogwood have been identified in the current Castalia collection. The similarity of ancient and modern forests strongly suggests closely parallel climatic and ground-water conditions.

The area where the specimens here reported on were collected is being strip mined for marl, leaving pits some 6 feet deep. In these pits two distinct forest layers may be seen. The upper lies from 2 to 4 feet below the original surface (i.e., before mining operations) and is composed of alternating black layers and gray marl, with many twigs, small logs, and much reedy material. Some 2½ to 4 feet below, lies a 6-inch-thick lower forest layer. See stratigraphy, p. 218.

Genera represented in the upper and lower forest layers are alike except for the occurrence of red cedar (*Juniperus virginiana*) in the latter. Whereas the upper layer consists of small to medium fragments (a few 6 inch logs) lying more or less horizontally, the lower layer contains medium to large logs (up to 12 inches in diameter) and several stumps which were clearly buried in place (fig. 8).

From a consideration of the genera represented in the Castalia collection, the vegetational makeup of the modern swamp forest community of northern Ohio, and what is known of the postglacial Lake Erie history, it must be assumed that the lower forest zone, at least, represents a community growing under conditions of rather high ground water, probably not far from the open lake, in a relatively mild climate not substantially different from that of the present time. Except for red cedar, it would be difficult to differentiate this forest of 8,500 years ago from others now living in northern Ohio. Then, as thick deposits of sandy marl were laid down in shallow, limy pools, this lower forest was drowned. Later—after an apparently fairly long interval because of the depth of material overlying the lower forest—surface drainage conditions improved somewhat, and there was a recurrence of a typical swamp forest formation.

SUMMARY

1. Spruce (*Picea*) logs, radiocarbon age "more than 37,000 years," from central Ohio indicate the same kind of cool-moist forest known to have existed later near the ice in the same region. On the other hand, two southwestern Ohio groups of Angiosperm remains, including oak (*Quercus*), ash (*Fraxinus*) and beech (*Fagus*), "more than 34,000" and "more than 40,000 years" in age, indicate warm conditions of unknown duration over 34,000 years ago for that region. There is no evidence that more than one such warm period is involved.

2. During the period 16,600 to 23,000 years ago, in southern and southwestern Ohio, there were extensive, though probably narrow, belts of evergreen forests with spruce (*Picea*) as the strong dominant. Tamarack (*Larix*) and white cedar (*Thuja*) were also present in small number. Remains examined included wood and needles.

3. These 16,600 to 23,000 year old forests were invaded by advancing ice and buried after only short transport. Study of their annual ring suggest an *average* speed of ice advance near its maximum southern limit of about 38 feet per year. Applications to problems of advance or retreat over very small distances are suggested.

4. Evidence is presented indicating early entry of a spruce or spruce-fir association in the wake of retreating ice in northern Ohio about 13,000 years ago, with no evidence of a tundra zone. Wood, needles, cones, and seeds were collected and studied. Drowning of these forests is evident, and their succession by broad-leaved formations as climate ameliorated is suggested.

5. Northern Ohio forests, and therefore climatic influences, by 8,500 years ago appear similar to those of the present.

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LITERATURE CITED

Braun, E. Lucy. 1951. Plant distribution in relation to the glacial boundary. Ohio Jour. Sci. 51: 139–146.

Hare, F. K. 1950. Climate and zonal divisions of the boreal forest formation in eastern Canada. Geogr. Rev. 40: 615–635.

Heusser, C. J. 1952. Pollen profiles from southeastern Alaska. Ecol. Monogr. 22: 331–352.
———. 1954. Additional pollen profiles from southeastern Alaska. Amer. Jour. Sci. 252: 106–119.
Lawrence, D. B. 1950. Glacier fluctuation for six centuries in southeastern Alaska and its relation to solar activity. Geogr. Rev. 40: 191–223.
Mathews, W. H. 1951. Historic and prehistoric fluctuations of alpine glaciers in the Mount Garibaldi map-area, southwestern British Columbia. Jour. Geol. 59: 357–380.
Potzger, J. E. 1951. The fossil record near the glacial border. Ohio Jour. Sci. 51: 126–133.
Rosendahl, C. O. 1948. A contribution to the knowledge of the Pleistocene flora of Minnesota. Ecol. 29: 284–315.
Sampson, H. C. 1930. Succession in the swamp forest formation in Northern Ohio. Ohio Jour. Sci. 30: 340–357.
Sears, P. B. 1930. A record of post-glacial climate in northern Ohio. Ohio Jour. Sci. 30: 205–217.
———. 1948. Forest sequence and climatic change in northeastern North America since early Wisconsin time. Ecol. 29: 326–333.
Wright, G. F. 1920. The Ice Age in North America. 6th Edition. Oberlin, Ohio. Bibliotheca Sacra Co. 808 pp.